Rocky Mountains
Southwest
Great Plains

Research Note RM-403

May 1981

USDA Forest Service

Rocky Mountain Forest and
Range Experiment Station

Acephate Residues in Second Year Cones of *Pinus sylvestris* L. Sprayed to Prevent Damage by *Dioryctria disclusa* Heinrich

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Residue analysis of homogenized cones and wash indicated that acephate (Orthene 75S)[2] and methamidophos were present in or on the cones for 10-15 days after spraying with acephate. Spray rates were 2 pounds per 100 gallons (2.36 g/l) and 4 pounds per 100 gallons of water (4.73 g/l).

Keywords: Acephate residues, methamidophos, Scotch pine, webbing coneworm, cone protection, systemic insecticides

Management Implications

The residues of acephate (O,S-dimethyl acetylphosphoramidothioate) and its metabolite, methamidophos (O,S-dimethyl phosphoramidothioate), present in and on Scotch pine (*Pinus sylvestris* L.) cones 10-15 days after spraying, should be sufficient to prevent damage by early instar larvae of the webbing coneworm (*Dioryctria disclusa* Heinrich). Even when very few *D. disclusa* were present, acephate applied at 2 pounds per 100 gallons of water apparently reduced feeding and tunneling damage to second year Scotch pine cones, while not reducing seed production per cone. However, because of the relatively low *D. disclusa* population during this test, additional tests must be conducted when populations are more abundant before test results would warrant a registration application for acephate to control *D. disclusa* on *P. sylvestris*.

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[2]The use of trade, firm, or corporation names in the publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

Introduction

Scotch pine, a widely distributed and economically important tree in Europe and Asia (Little 1979), has been introduced into the United States for use in shelterbelts and plantations and as an ornamental. The USDA Forest Service is developing improved varieties of Scotch pine for use on the Great Plains in shelterbelts and as Christmas and ornamental trees.

Tree improvement research is particularly hampered when high value, control pollinated cone crops are lost or reduced by insect infestations, such as the webbing coneworm. The young larvae of this moth initially feed on the staminate cones until lack of food forces them to migrate to second year cones. Each larva may feed on as many as two Scotch pine cones, damaging portions or entire cones (Mattson 1976). Damaged cones may produce fewer seeds or abort before reaching maturity.

Acephate (Orthene 75S), a systemic insecticide which is toxic to a variety of forest insect pests (Brown and Eads 1975, Brown et al. 1978, Neisess et al. 1976, Brewer and O'Neal 1977, and Richmond et al. 1979), has both systemic and contact activity on some species of conifers (Richmond et al. 1978). This paper describes the insecticide residue levels found on the surface of intact cones and extracted from the homogenized tissue of cones sprayed with acephate.

Methods and Materials

Study Area

In 1963, the USDA Forest Service established a provenance test of Scotch pine on the Denbigh Experimental Forest in North Dakota as part of the search for species adapted to the northern Great Plains climate. By 1977 the trees were 23-28 feet (7.0-8.5 m) tall, about 6.0 inches (15.2 cm) d.b.h., with a 10- to 12-foot (3.0-2.7 m) crown diameter.

Insecticide Application

In 1977, crews sprayed with acephate nine plots containing at least three trees per plot. Selection was made without regard to seed source. The only requisite was that each candidate tree bore at least 30 first-year conelets. The young trees were just beginning to bear good seed crops, and production was variable among trees. To avoid cross contamination of insecticide treatments, plots were separated by at least three trees.

Each of the following treatments was applied to three plots selected at random:

(1) Control (not sprayed).
(2) 2 pounds acephate per 100 gallons of water (2.36 g/l).
(3) 4 pounds acephate per 100 gallons of water (4.73 g/l).

Crews sprayed all treated trees when the air was calm on May 6, 1977, approximately one week before anthesis. The entire crown of each noncontrol tree was sprayed to the point of runoff with a 50 pounds per square inch hydraulic sprayer. Personnel reached the tree crowns by means of a maneuverable bucket on a truck-mounted boom.

Residue Analysis

Treatments and controls were sampled for residue analysis on the day of spraying (day 0), and at 1, 5, 10, 17, and 30 days after spraying. Because of the high cost of residue analysis, only two of the three plots were used. Each sample contained 30 cones randomly selected from each treatment, or 5 cones from each tree. The 30 cones in each sample were packaged together and immediately refrigerated.

Each 30-cone sample was divided into 3 sets (10 cones per set), which were washed 3 times with 200 ml distilled water. The washes were extracted and analyzed to determine the amount of surface insecticide residue, expressed as micrograms per sample because the amount of residue represented a measurement of deposit on the surface of the cones. The amount of insecticide recovered from the water wash is a function of surface area, not cone weight, hence it cannot be expressed in parts per million. Following the surface wash, the whole cones were homogenized (ground up), extracted, and characterized by gas liquid chromotography (GLC), using previously established methods (Richmond et al. 1978, Richmond et al. 1979). Residues extracted from the whole cone homogenate were assumed to have penetrated directly into the cone and can be expressed in parts per million. The analytical procedures used for extraction and characterization of acephate also extract and detect methamidophos, a toxic metabolite. Each sample was analyzed three times and the content of acephate and methamidophos calculated as the average of the three GLC readings. Then the average proportions of acephate and methamidophos for the two replications were calculated. In addition, small quantities of both acephate and methamidophos were added to untreated cone tissue prior to washing and homogenizing to determine the percent recovery of the extraction method.

Cone Protection and Insecticide Phytotoxicity

A second sample of 30 cones randomly picked but equally distributed among the study trees was examined for *D. disclusa* larvae and their damage on day of spraying (day 0), and 1, 5, 10, 17, and 30 days after spraying. The presence of *D. disclusa* larvae or insect damage on the 30-cone sample was recorded. While examining the cones for larvae and damage, crews also examined the trees for unusual browning, needle drop, or unusual growth.

In July 1977, the remaining cones on each tree in each treatment were checked for insect damage. In September, the cones were collected. The number of seeds per cone was counted, and the percent sound seed per cone was calculated for each tree. Sound and empty seed were separated using a seed blower, with accuracy of separation checked by cutting open subsamples of seeds and by x-raying subsamples of seeds.

Treatments were compared using an analysis of variance and the Student Newman Keuls Test. Bartlett's test for homogenous variance was performed on all data (Steel and Torrie 1960, Sokal and Rohlf 1969).

Results and Discussion

Residue Analysis

The overall mean percent recovery of methamidophos in tissue to which methamidophos had been added was 75.1% (SD = 6.28), while that for acephate in the tissue to which acephate had been added was 80.8% (SD = 3.53). Because the amount of methamidophos in sprayed cones was never more than 0.61 p/m and decreased with time, that amount was added to the acephate concentration to give the total amount of insecticide recovered by date and treatment in micrograms per sample, or parts per million (figs. 1 and 2).

The concentration of acephate which will kill 50% of the test insects, or LC_{50}, for *D. disclusa* is unknown. However, the LC_{50} for sixth stage larvae of the western spruce budworm (*Choristoneura occidentalis* Freeman) is 7.7 p/m (Richmond et al. 1978). If we assume the LC_{50} dose for early stage *D. disclusa* larvae is similar to

sixth stage budworm larvae, this lethal concentration of acepand methamidophos would have remained in the cones for about 14 days after spraying at both the 2-pound rate and the 4-pound rate (fig. 2). DeBarr and Fedde (1980) found that LC_{50} for first stage *Dioryctria amatella* (Hulst) larvae, a related species, is about 1 p/m for Guthion, 6.5 p/m for carbofuran, and 12 p/m for phosmet. Although the budworm and coneworm larvae are different instars and different families, an LC_{50} level of 7.7 p/m acephate for *D. disclusa* and *C. occidentalis* is comparable to the LC_{50} levels of these insecticides with *D. amatella.*

Detectable residue levels remained on the surface of the cones for 9-15 days following treatment (fig. 1). There was little difference between treatments, indicating that the 2 pounds a.i. per 100 gallons rate would be as effective as 4 pounds a.i. per 100 gallons (fig. 1 and 2). No significant acephate and methamidophos residues were detected beyond 15 days after application indicating that the tree had either metabolized the acephate or the acephate had broken down.

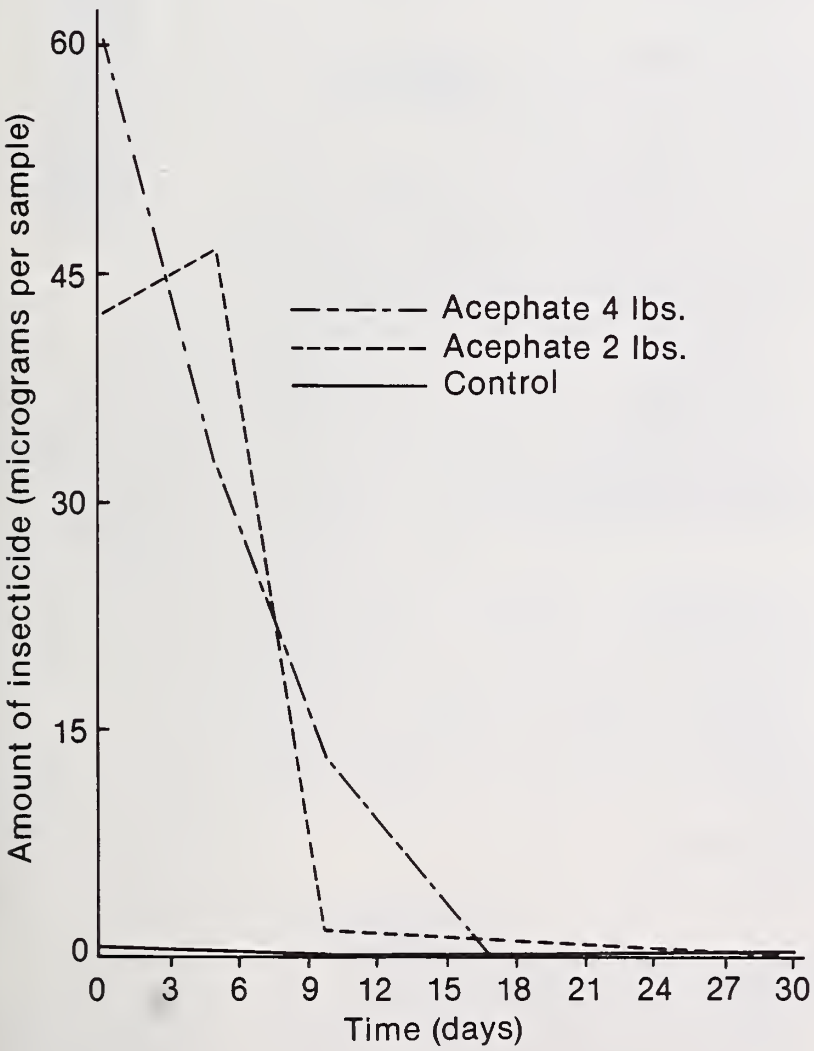

Figure 1.—Combined residues of acephate and methamidophos from water wash of cones of Scotch pine sprayed by ground application for suppression of webbing coneworm. Residues expressed as micrograms per sample, represent amount of insecticide deposited on the surface of the cones following treatment. The plotted line of values for the control trees cannot be distinguished from the abscissa.

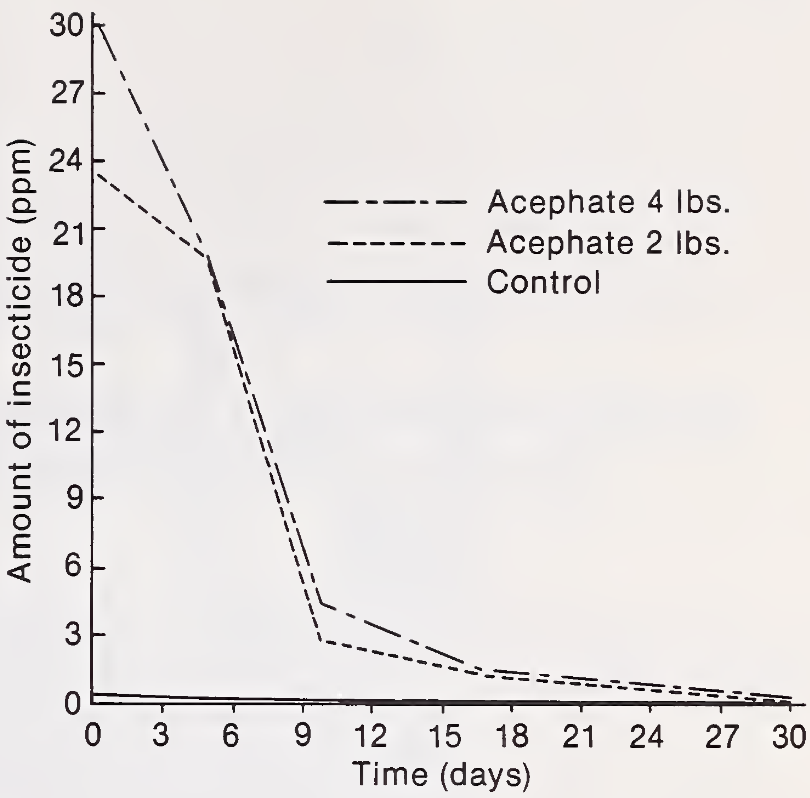

Figure 2.—Combined residues in parts per million of acephate and methamidophos from homogenized cones of Scotch pine sprayed by ground application for suppression of webbing coneworm. Residues represent amount of insecticide which penetrated into the cones. The plotted line of values for the control trees cannot be distinguished from the abscissa.

Cone Protection

The *D. disclusa* population in the study plot greatly declined between June of 1976 and June 1977, so the effect of acephate on larvae was almost impossible to obtain. No damaged cones were collected until the 30-day posttreatment sampling when four damaged cones were collected in the control sample. None of the treated cones in this sample was damaged. Several larvae were first observed on nontest trees in the plantation plot 12 days after spraying and these were in a late instar stage. Only a few larvae were observed on test and nontest trees at later dates.

Scotch pines in the control plots had significantly more cones on the entire tree with *D. disclusa* damage than did trees which received the acephate 2-pound and acephate 4-pound treatments (table 1). Although the treatments were randomly assigned to plots, the acephate 2-pound plots had fewer cones per tree, but this difference was not significant.

Phytotoxic Effects of Insecticides

No discoloration, unusual needle drop, or abnormal growth was observed on any of the trees sprayed with acephate. The number of seeds per cone did not vary significantly among treatments. The percentage of sound seed per cone decreased at the 4-pounds-per-100-gallons rate (table 2).

Table 1.—*Dioryctria disclusa* damaged cones on Scotch pine trees in July

Treatment	Trees	Cones				
		Total checked	Crop per tree		Damaged[1]	
	------------------ number ------------------			SD	percent	SD
Control	9	1267	140.8	133.89	4.15 a	2.03
Acephate 2 pounds per 100 gallons water	10	798	79.8	60.99	0.67 b	1.99
Acephate 4 pounds per 100 gallons water	10	1760	176.0	75.65	0.66 b	2.12

[1]*Means followed by different letters vary significantly at the 5% level according to the Student Newman Keuls test. Bartlett's test for homogenous variance was not significant ($X^2 = 0.2$, df = 2).*

Table 2.—Effect of acephate on Scotch pine seed production

	Seed per cone		Sound seed per cone			
	Mean number	SD	Mean number	SD	Mean percent[1]	SD
Control	22.8	10.92	21.3	10.27	92.5 a	4.45
Acephate 2 pounds per 100 gallons water	21.9	8.37	19.8	7.47	90.1 a	4.18
Acephate 4 pounds per 100 gallons water	18.2	9.99	14.1	8.77	74.4 b	13.41

[1]*Means followed by different letters vary significantly at the 5% level according to the Student Newman Keuls test.*

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Pesticide Precautionary Statement

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some states have restrictions on the use of certain pesticides. Check your state and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or state extension specialist to be sure the intended use is still registered.

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